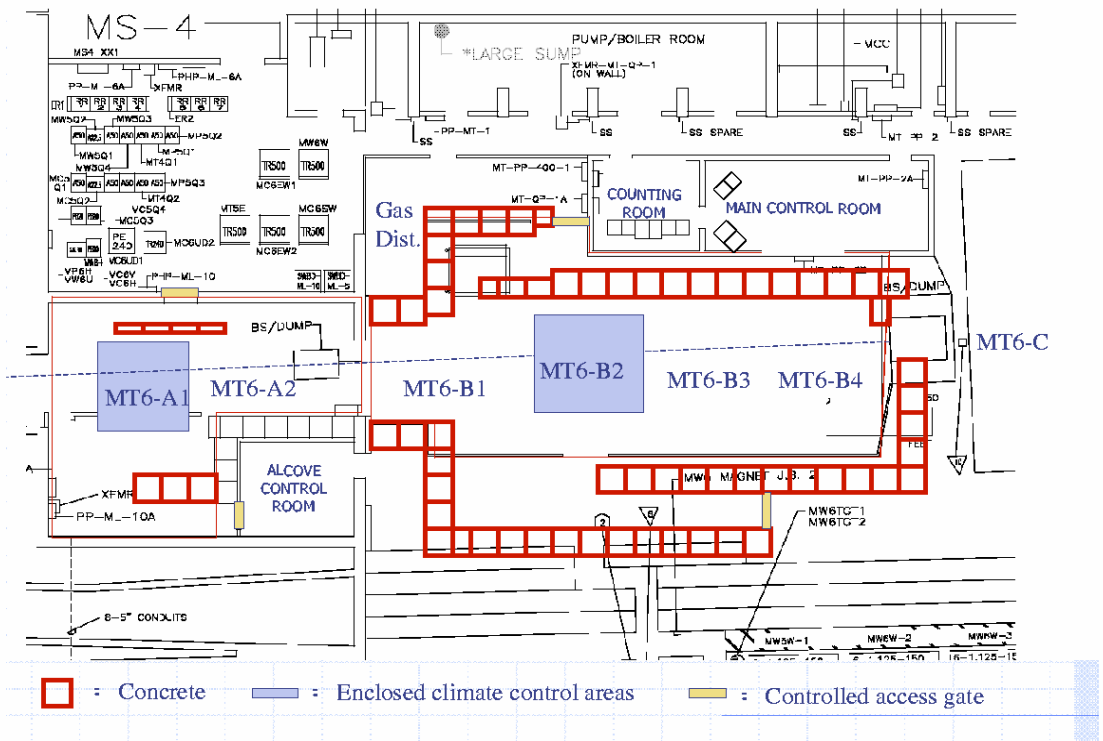
Recent Activity in the Test Beam

Erik Ramberg
AEM
1 May, 2006

- Quick overview of facility
- Preliminary results from experiments that have taken beam so far this year
- New experiments likely to take beam this year
- Updates to beamline

The Facility

MT6 Test Beam User Areas



- 2 beam enclosures, but cannot be operated independently.
- 6 user stations, with a 7th downstream of the beam dump. An experiment can take up more than one station.
- 2 climate stabilized huts with air conditioning.
- 2 separate control rooms.
- Outside gas shed + inside gas delivery system brings 2 generic gas lines, 1 nitrogen line and 2 exhaust lines to each of the user areas
- Lockable work area with 3 offices for small scale staging or repairs, plus 2 open work areas.

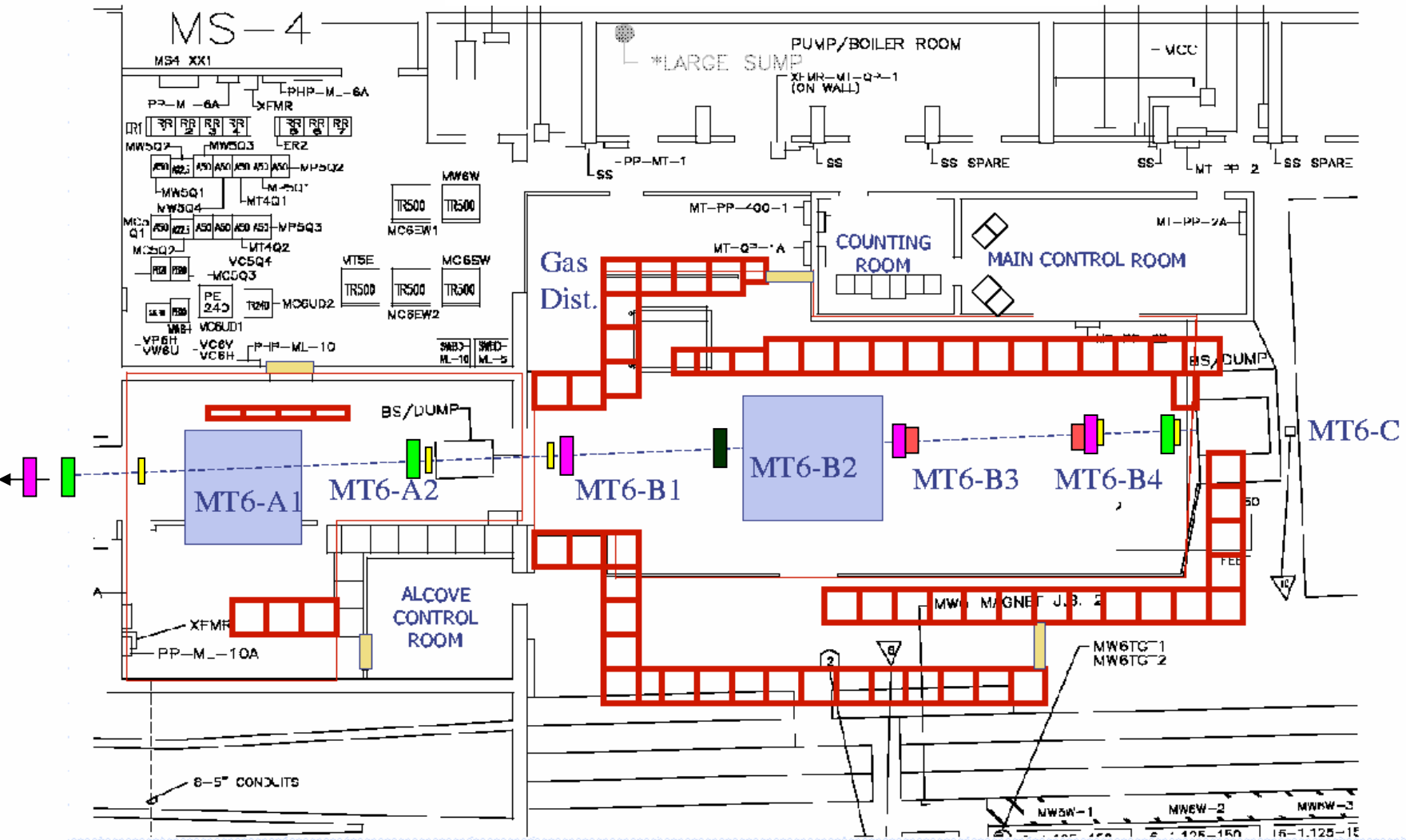
Measured rates in the MTBF beamline

Tune (GeV)	Rate in MT6/spill*	e^- fraction	Resolution in ECAL
120	800,000	0	-
66	90,000	0	-
33	40,000	0.7 %	1.0 %
16	14,000	10 %	1.2 %
8	5,000	30 %	-
4	500	60 %	2.4 %

* (Rates are normalized to 2.4E12 protons in Main Injector)

Spill is 4 seconds long, every 2 minutes

MTBF Detectors



: Concrete : Enclosed climate control areas : Controlled access gate

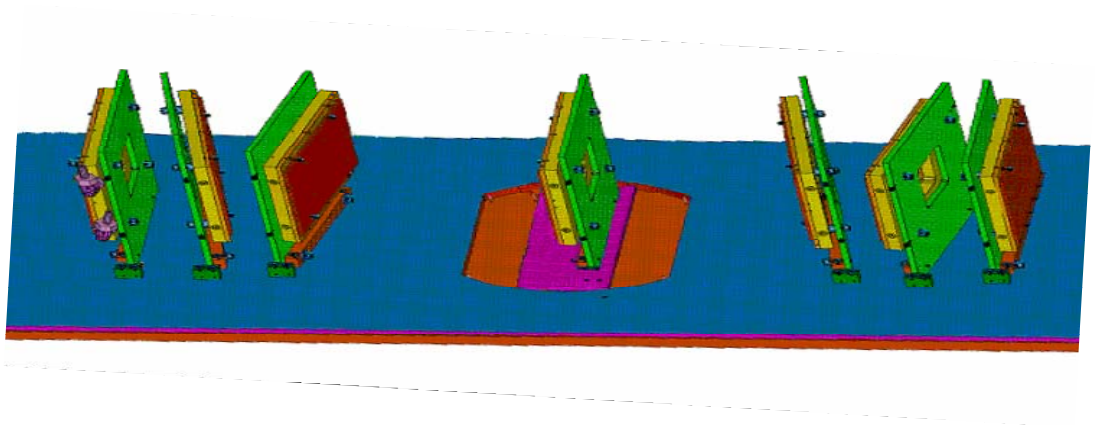
Scint. PWC Finger counters Swic SSD

Current Experiments

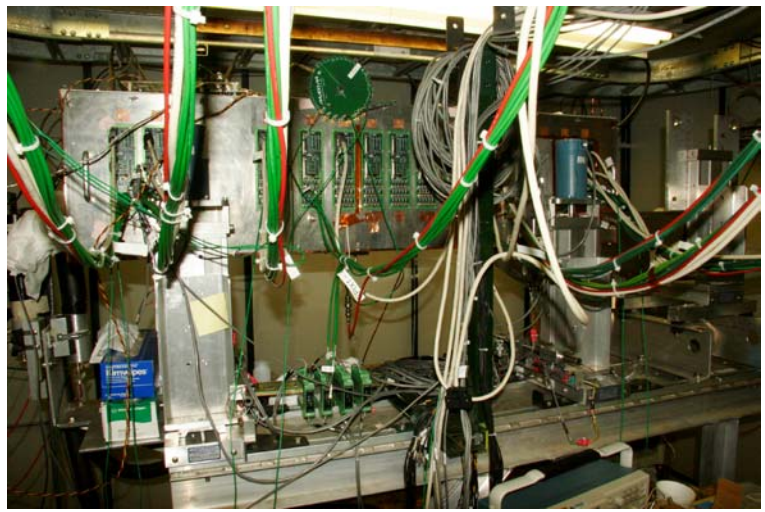
List of MTBF Memoranda of Understanding (MOU):

T926: RICE Experiment completed
T927: BTeV Pixel Experiment completed
T930: BTeV Straw Experiment completed
T931: BTeV Muon Experiment completed
T932: Diamond Detector Signed
T933: BTeV ECAL Experiment completed
T935: BTeV RICH Experiment completed
T936: US/CMS Forward Pixel Taking data
T941: UIowa PPAC Test Experiment completed
T943: U. Hawaii Monolithic Active Pixel Detector Experiment completed
T950: Kaon Vacuum Straw Tracker Analyzing data
T951: ALICE EMCAL Prototype Test Analyzing data
T953: U. Iowa Cerenkov Light Tests Analyzing data
T955: RPC Detector Tests (Argonne) Taking data
T956: ILC Muon Detector Tests (Indiana) Taking data
T957: ILC Tail Catcher (NIU) Taking data

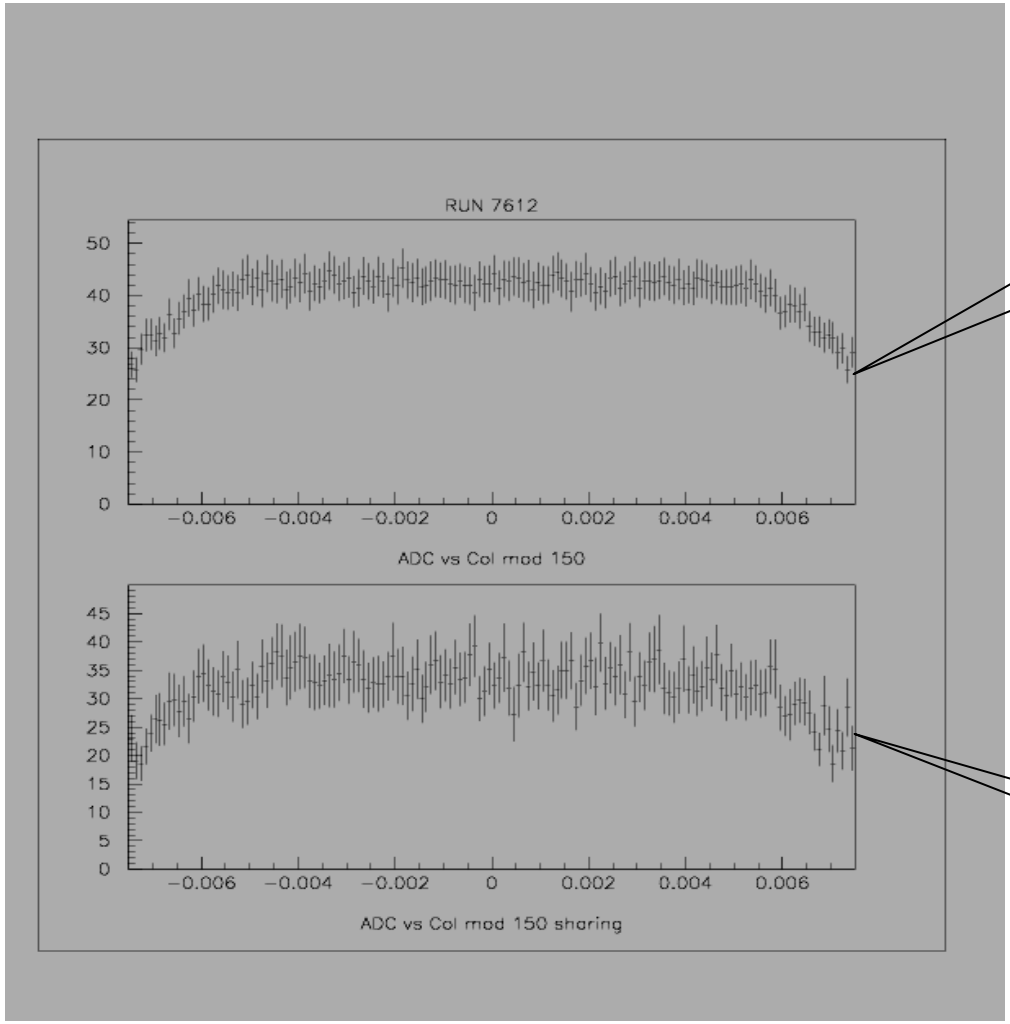
T927/936: The CMS pixel setup (INFN)



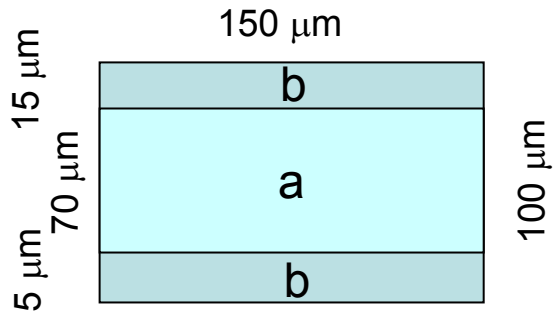
- Telescope of 6 pixel detectors (50 μm × 400 μm)
  - 2 Y-measurement planes
  - 4 X-measurement planes
- CMS pixel detector in the center (100 μm × 150 μm)
- Triggers to CMS detector are provided by two upstream scintillators



Pulse Height across cells



Tracks pointing to region a



Tracks pointing to region b

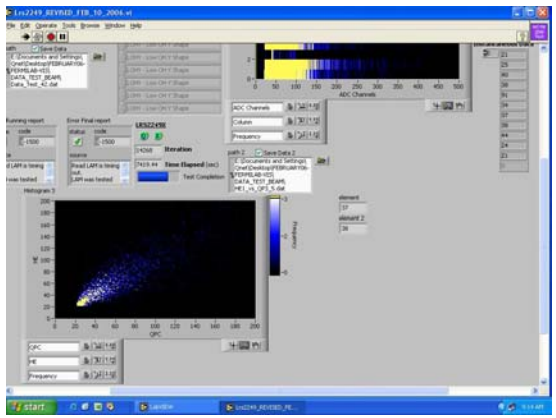
Note that the edges of the irradiated cells show the expected charge loss due to charge sharing with adjacent cells.

Conclusions

- The first analysis of data collected at the January test-beam indicates that
  - The plaquettes irradiated @ 3×10^{13} work well and show no significant signs of damage
  - They provide a detection efficiency very close to 100% @ 150V.
- Additional near-term irradiations and beam tests are planned. Next scheduled tests are in July.

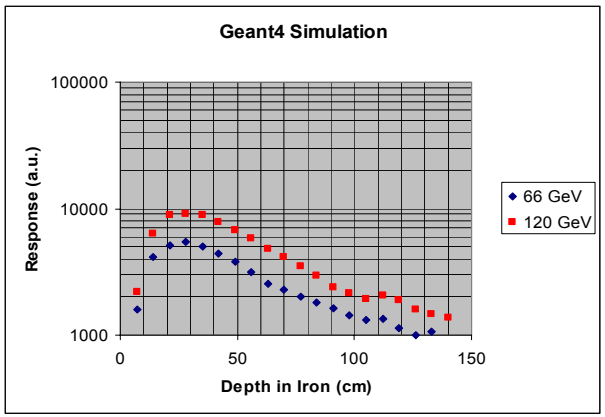
T953: CMS Calorimeter Upgrade (Iowa)

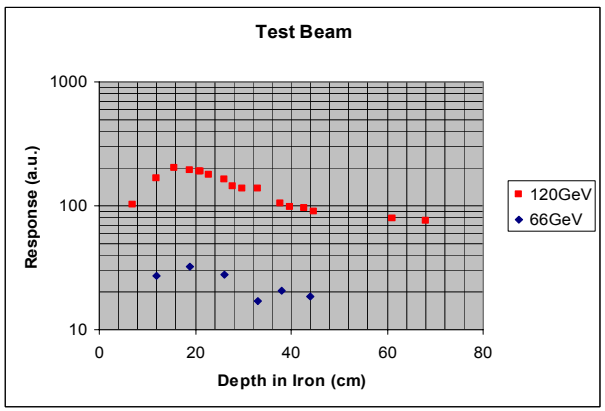
- Although we have only 6 layers, we got data at different depths (up to 70 cm of iron).
- We developed our own DAQ with NIM, CAMAC and LabView. At M-Test we had opportunity to test it.



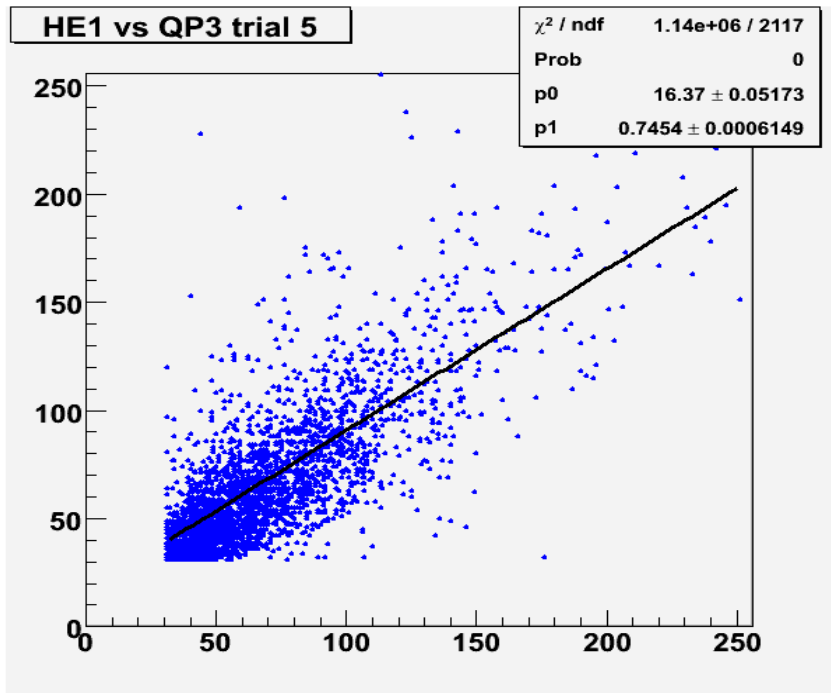
Results from Test Beam @ Fermilab M-Test

- With limited number of layers we observed a shower profile at 120 GeV.
- The 66 GeV has very low statistics

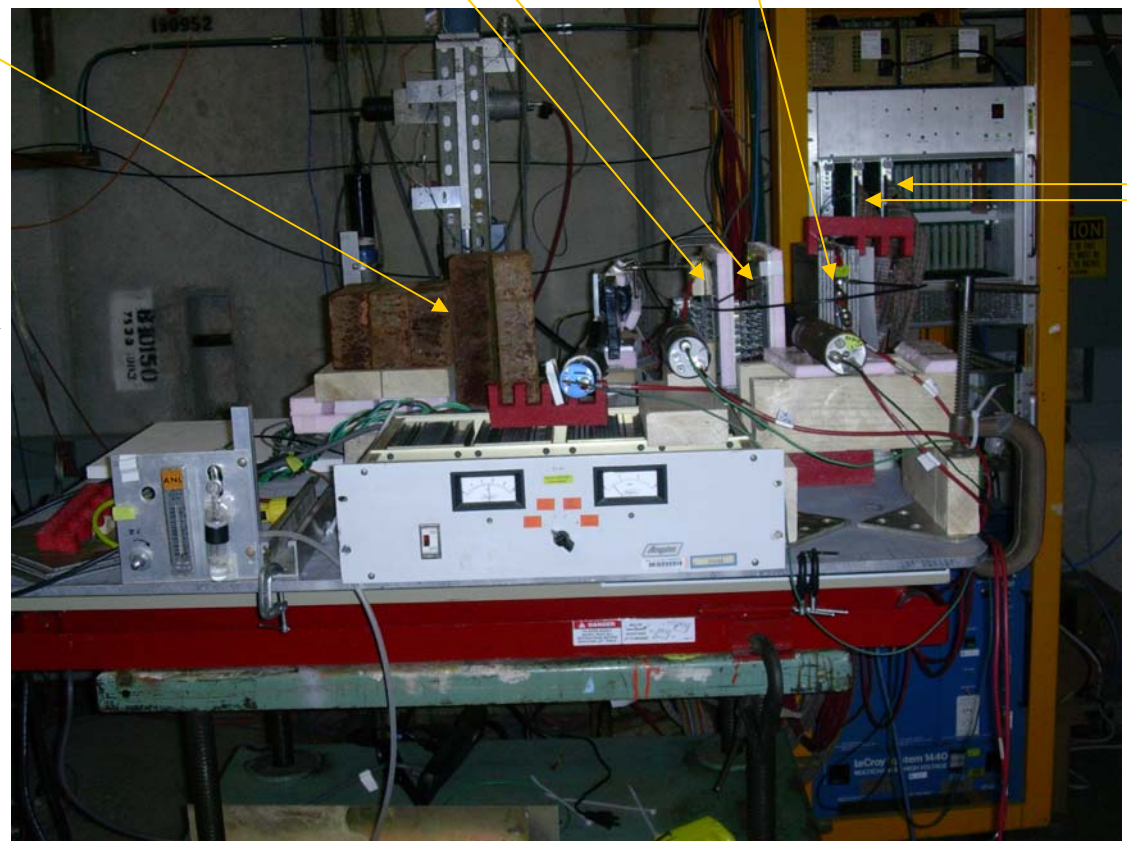




- We compared the quartz plates with scintillators at different shower depths.
- We showed that the Cerenkov light collection is comparable with scintillation light.
- Plan to bring full calorimeter (20 layers) to MTest in Fall, 2006.

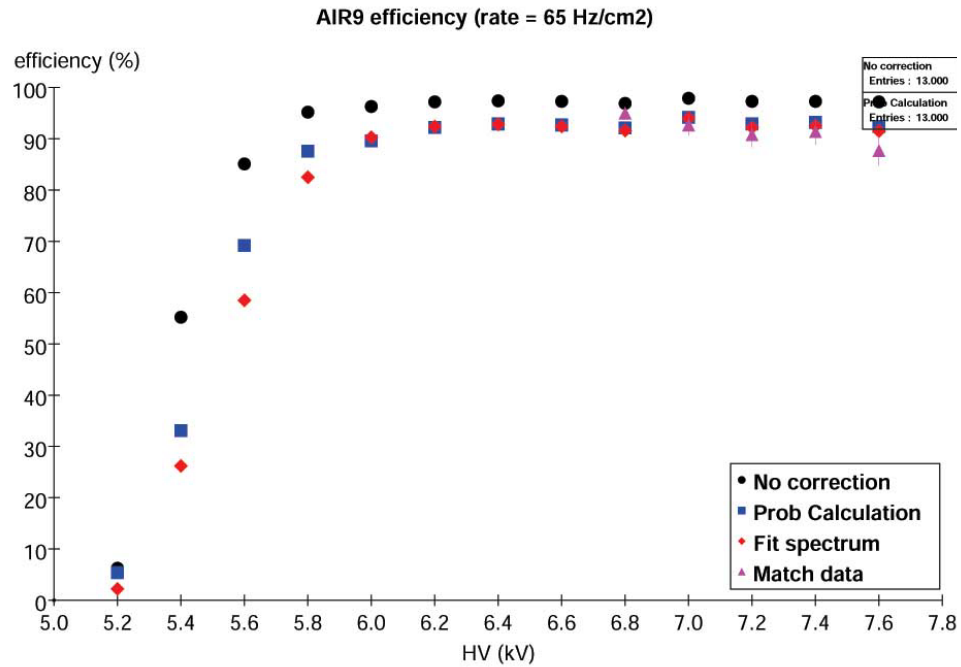


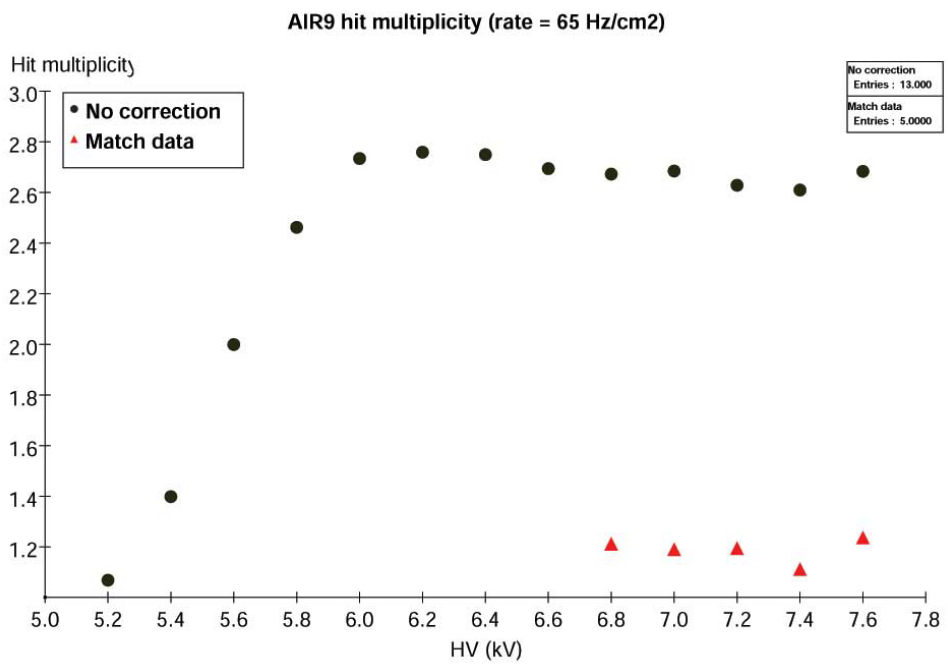
T955 – ILC RPC Tests in MT6 (Argonne)



- Taken data with 120 GeV proton and 16 GeV pion, at beam intensity 60 – 5k Hz/cm^2
- Tested 3 RPCs, this talk will cover the results from the first 2 chambers

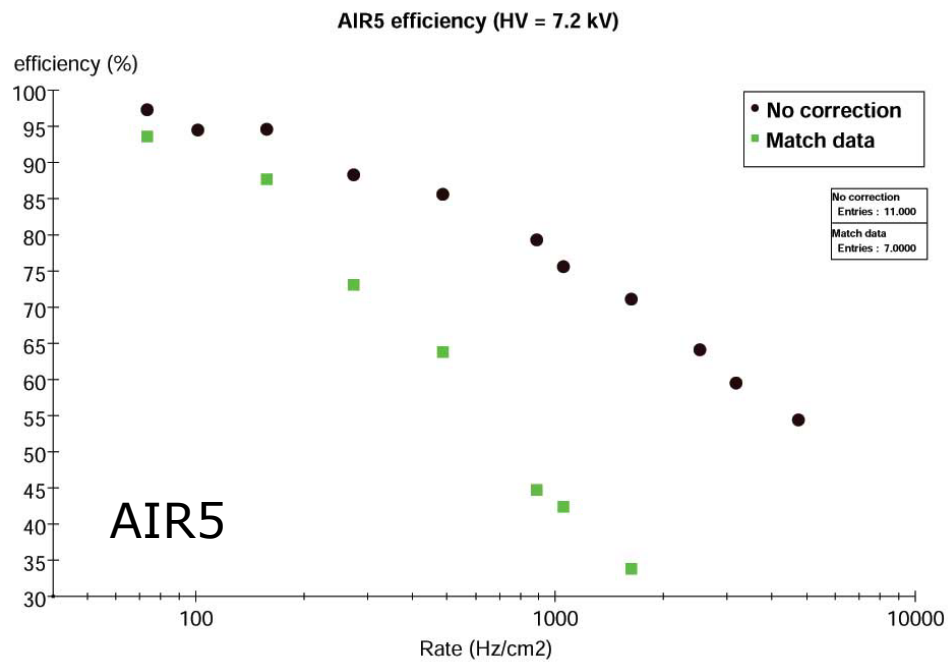
AIR9: efficiency and hit multiplicity

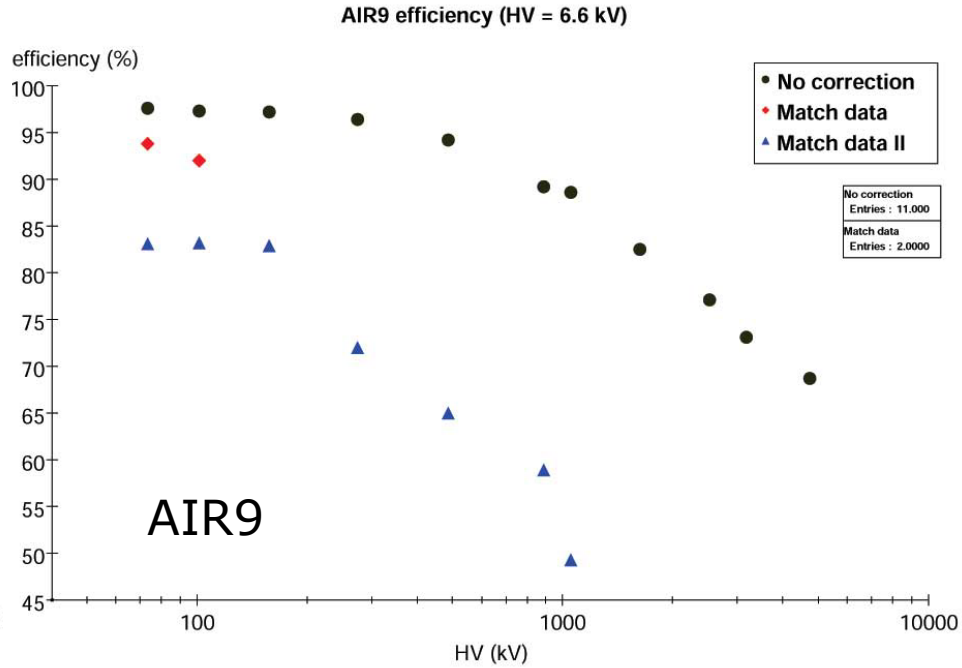




- Efficiency measurement
  - ~92%, consistent with cosmic ray tests
  - All method agrees for HV>6kV
  - Prob. Calculation over estimate at low HV (as expected from method)
- Hit multiplicity m~1.2
  - Should be treated as an upper limit
  - Consistent with cosmic ray tests m~1.1

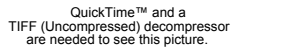
‘High’ rate measurement



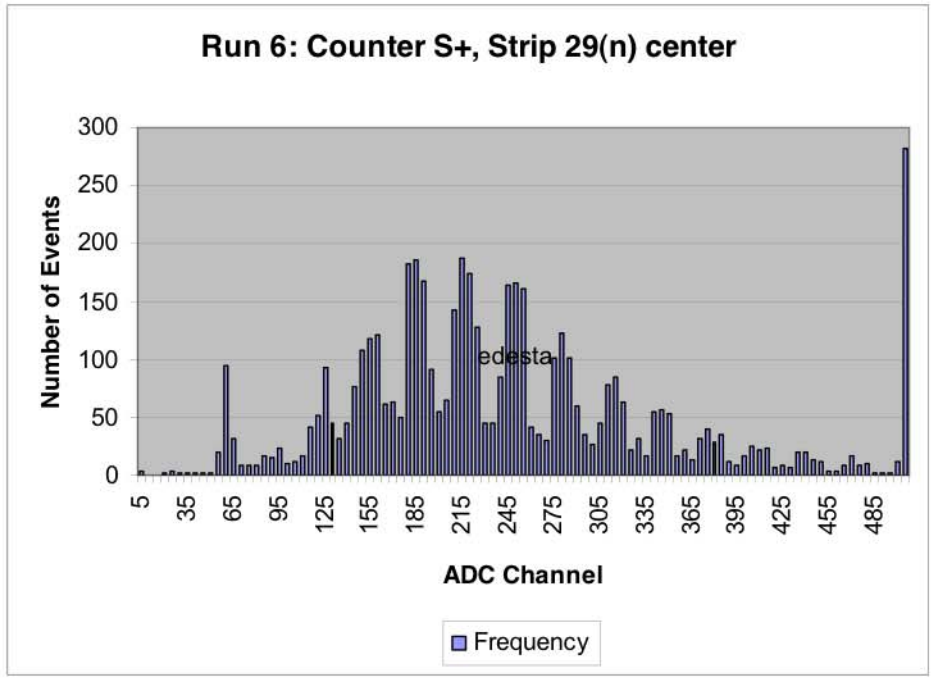


- AIR5
  - Efficient up to 100Hz/cm2
  - If operated at 7.4 kV, better rate capability expected
- AIR9
  - Match data: only provide first two data points
  - Match data II: tells how efficiency changes with rate, but significantly underestimate absolute value
  - Should be efficient for 100-200Hz/cm2

T956: ILC Muon Detector Test (Indiana/FNAL)



Preliminary Result – ADC Spectrum, 5000 events



- Pedestal at ~channel 65, with 10X amplifier
- Peaks at ~channels 95, 125, 155, 185, 215, 245, 275, …
- Correspond to 1, 2, 3, 4, 5, … photoelectrons
- Mean number of photoelectrons is ~6
- At 0.25 pC/channel, 30 channel separation between peaks yields gain of 4.5×10^7 (amplified), or 4.5×10^6 (unamplified)

T957 - CALICE TCMT (NIU)

("TCMT"=Tail Catcher/Muon Tracker)

Stack designed and being assembled at Fermi

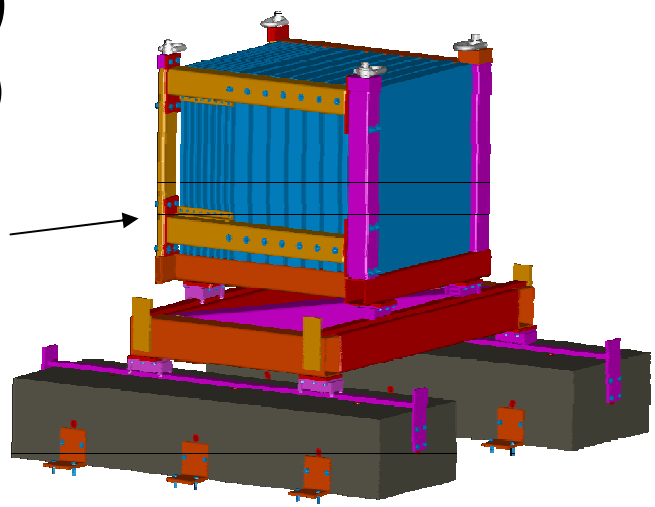
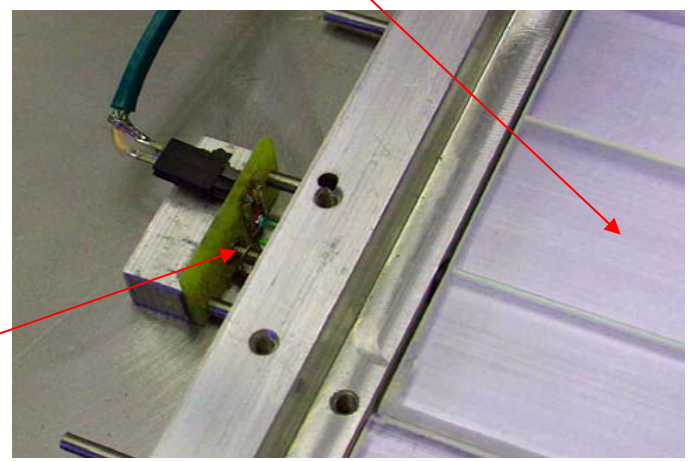


Diagram of Full Detector

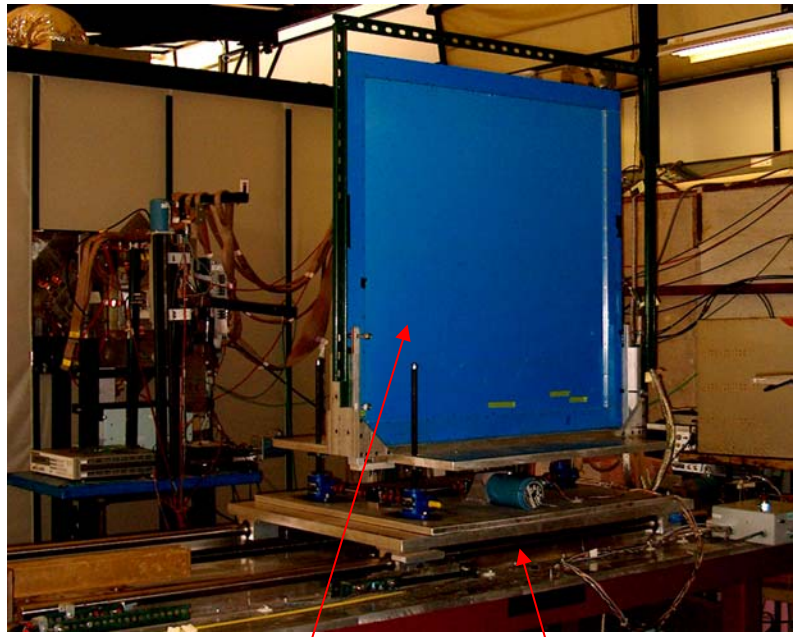
- **Designed to test new detector technology (extruded scintillators, Silicon photomultipliers) for the ILC**
- **Sixteen 1m x 1m 'cassettes', each of which has 10 scintillating strips and 20 photosensors, are separated by steel absorber plates**
- **A single cassette was installed at the FNAL Meson Test Beam Facility in February for initial evaluation in a 120GeV proton beam**

Extruded Scintillator



Silicon Photomultiplier

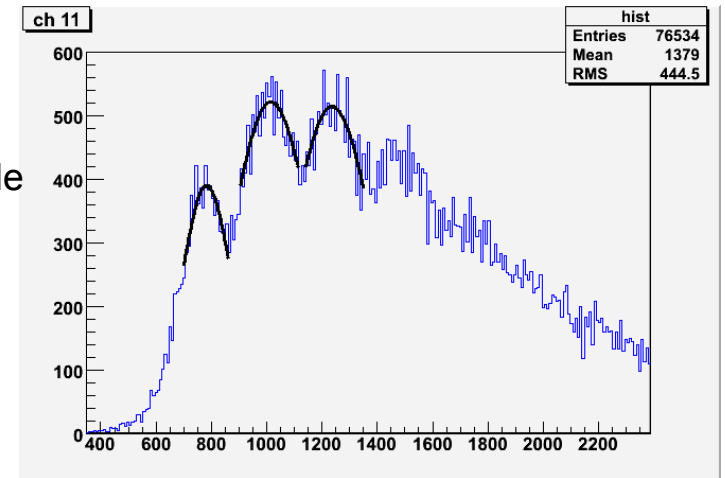
- Moved into the facility 3rd week of Feb.
- Took beam in the last week ~ 5 days
- Took 120 GeV/c protons, 16 GeV/c (mostly pions) and some beam dump muon runs
- ~ 1M events collected
- Calice DAQ Electronics chain reproduced and tested
- Results will be compared with 3 GeV/c e- data from DESY
- Will attempt to run at CERN in July, if SiPM chips are available.
- Likely future running at MTest with multiple layers.



TCMT cassette at MTBF

Motion table

Calibration data showing single Photoelectron separation



Potential New Experiments

Fast Timing (20 ps) Cerenkov Counters

FP420:http://www.fp420.com

Aim: For eventual upgrade to CMS (and ATLAS), measure very forward protons 420m from intersection.

$$pp \to p + H + p, \quad p + W^+W^- + p$$

$$\sigma \approx 3 - 10 \text{ fb} \qquad \sigma \approx 50 \text{ fb}$$

Precise measurements of forward protons gives information on M(H), Spin and CP, Couplings and Width if > few GeV.

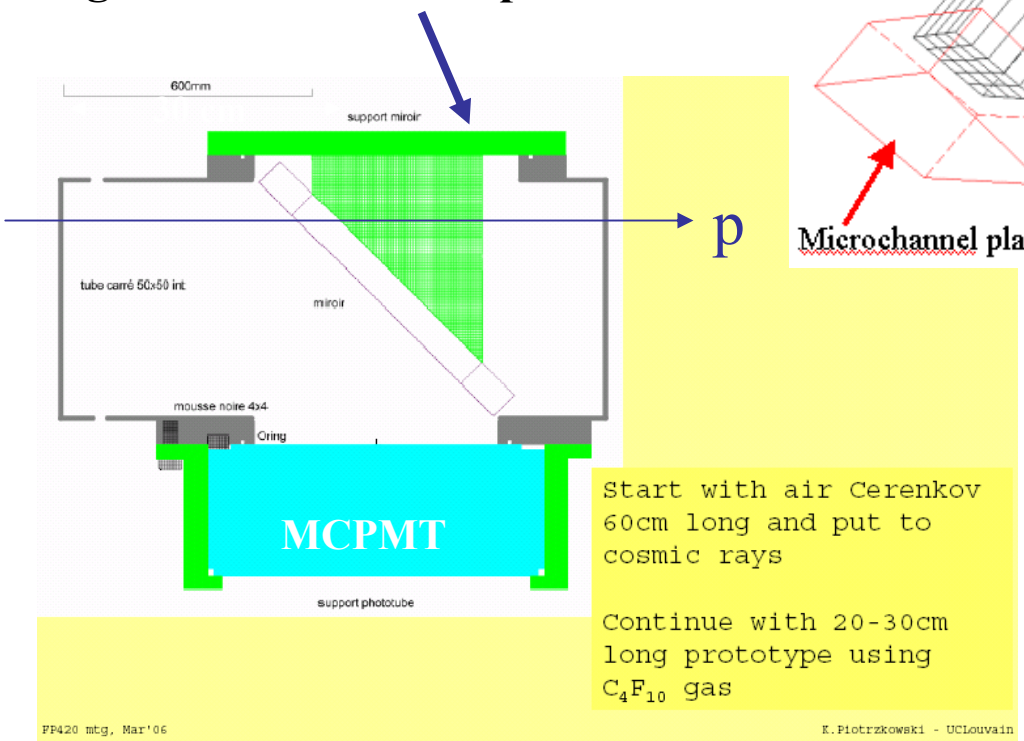
Detector area only 8 mm x 24 mm, need ~ 10 μ tracking and < ~ 20 ps timing to reduce accidentals.

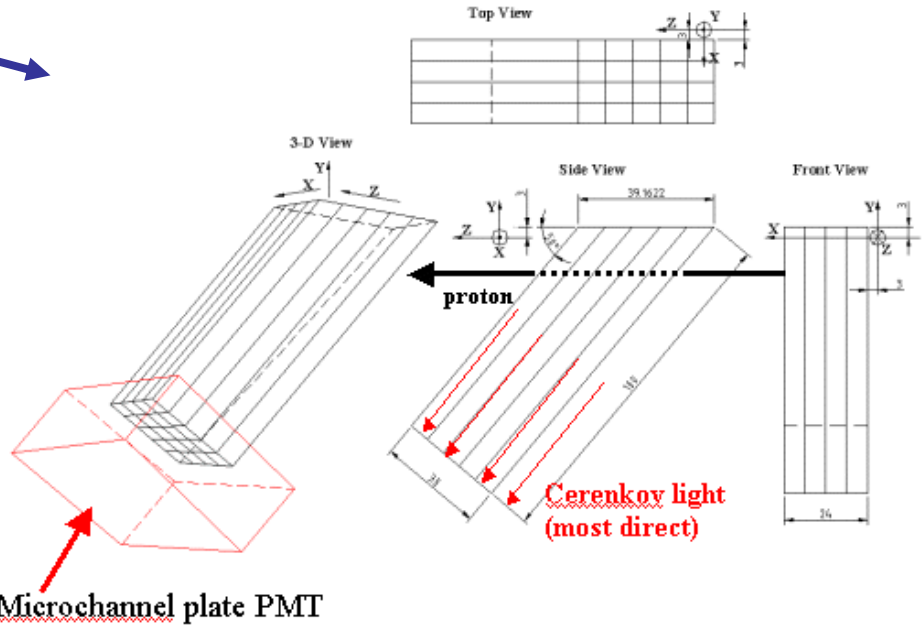
$$\Delta t \approx 20 \text{ ps} \to \sigma(z_{vertex}) \approx 4.5 \text{ mm}$$

$$cf\ \sigma_Z(\text{interactions}) \approx 55 \text{ mm}$$

QUARTIC = QUARtz TIming Cerenkov
6mm x 6mm bars mounted
at Cerenkov angle 50deg.

GASTOF:
Cerenkov angle small →
less light, make long (30 cm)
Light arrives within 2 ps.



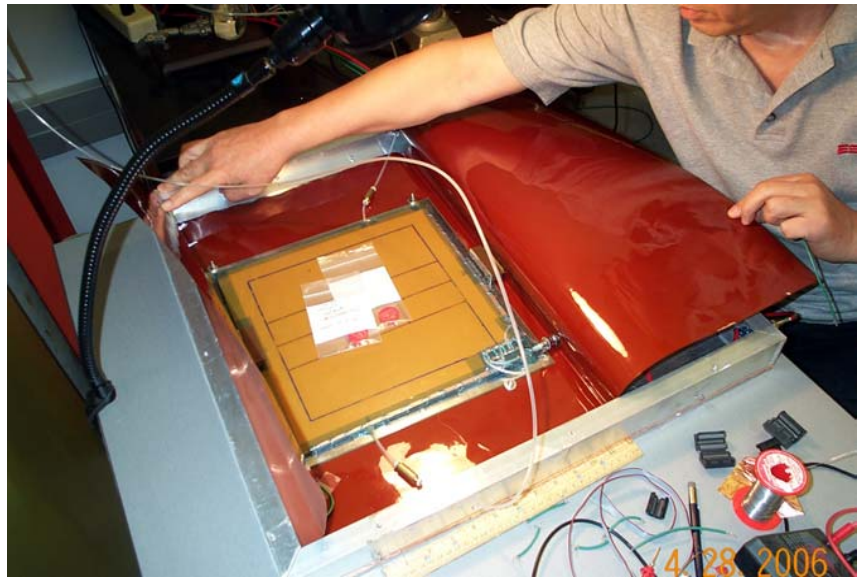


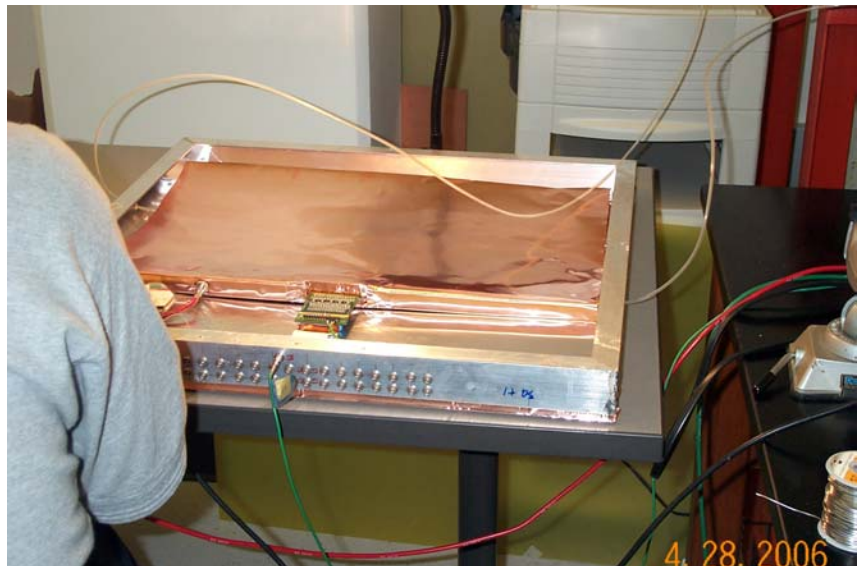
Burle 2" MCPMT
6mm x 6 mm pixels

Plan to test prototypes counters Summer/Fall 2006 . High energy protons only. Co-exist with CMS pixel tests.

GEM 30cmx30cm Prototype Chamber (U.T.A.)

- The first 30cmx30cm GEM chamber constructed with 3M foils
- Tested with sources
- Will be used low E electron beam chamber and 3M foil characteristics run in Korea in mid May
- 16 channel will be read out



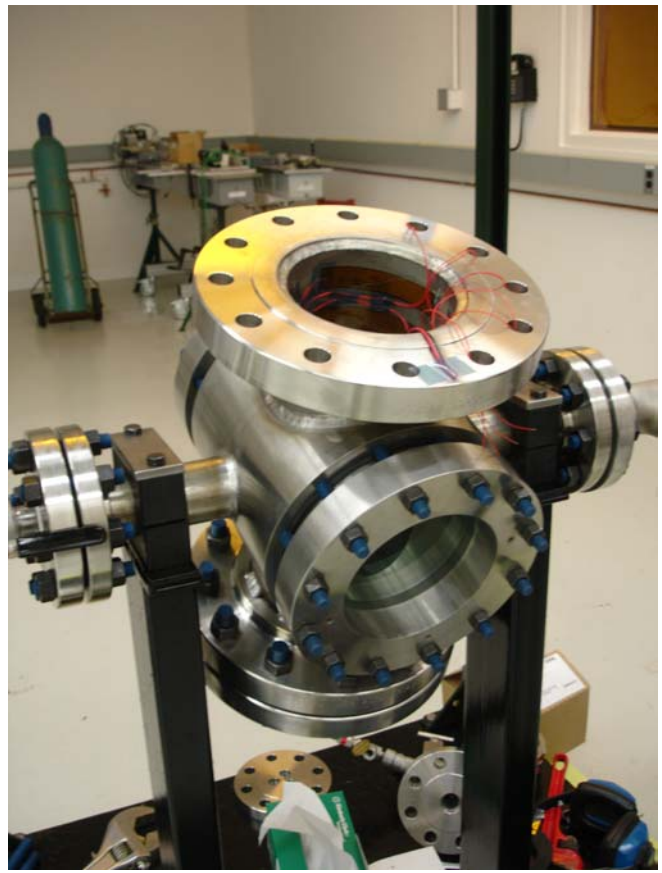


FNAL Beam Test Plans

- Late July or early August, 2006
- Use two chambers
- Use new PCI based ADC card with 96 channel readout
- Expose to e, π and muons
  - Energies in as wide momentum range as possible
  - Will expose chambers with large bricks in front of the chambers or with some absorber plates between them
  - Will allow us to see chamber behaviors with hadronic and EM showers
  - Verify chamber characteristics measurements in Korea

COUPP bubble chamber nuclear recoil efficiency measurement

- A new bubble chamber is being built by the COUPP collaboration
- Plans are to use it for tests of efficiency and nuclear recoil thersholds.
- One of the best ways to measure recoil energy spectrum of events is to use coherent nuclear scattering, with an incoming low energy (10 GeV) pion beam.



An ILC test beam plan – 34 institutions, ~160 names

IV. Personnel and Institutions

The following Tables 2.a and 2.b list all participating institutions and the names of the physicists involved in the test beam program at Fermilab in this proposal. CALICE collaboration is by far the largest single-organization in this test beam program.

Table 2.a Part one of the list of institutions and personnel participating in ILC calorimeter program.

Institutions/Collaborations		Personnel Names
CALICE	Argonne National Laboratory	S.Chekanov, G.Drake, S.Kuhlmann, S.R.Magill, B.Musgrave, J.Repond, D. Underwood, B Wicklund, L. Xia
	University of Texas at Adington	A.Brandt, K.De, V.Kaushik, J.Li, M.Sosebee, A.White, J.Yu
	Nothern Illinois University/ NiCADD	G. Blazey , D. Chakraborty, A. Dychkant, A. Maciel, M. Martin , R. McIntosh, V. Rykalin, V. Zutshi
	University of Birmingham, UK	C.M.Hawkes, S.J.Hillier, R.J.Staley, N.K.Watson
	Cavendish Laboratory Cambridge University, UK	C.G.Ainsley, G.Mavromanolakis , M.A.Thomson, D.R.Ward
	Laboratoire de Physique Corpusculaire – Clermont	F.Badaud, G.Bohner, F.Chandez, P.Gay, J. Lecoq, S.Manen, S.Monteil
	Joint Institute for Nuclear Research – Dubna, Russia	V.Astakhov, S.Golovatyuk, I.Golutvin, A.Malakhov, I.Tyapkin, Y.Zarevski, A.Zintchenko , S.Bazylev, N.Gorbunov, S.Slepnev
	DESY – Hamburg, Germany	G.Eigen, E.Garutti, V.Korbel, R.Poeschl, A.Raspereza, F.Sefkow
	Hamburg University, Germany	M.Groll, R.-D. Heuer, S.Reiche
	Kangnung National University – Kangnung, Korea	G.Kim, D-W. Kim, K.Lee, S.Lee
	Imperial College London, UK	D. Bowerman, B. Cameron, P. Dauncey, D.Price, O. Zorba
	University College London, UK	S. Bogaert, J.M.Butterworth, D.J.Miller, M.Postranecky ,M.Warren, M.Wing
	University of Manchester, UK	R.J.Barlow, I.P.Duerdoth, N.M.Malden ,D. Mercer, R.J.Thompson
	University of Minsk, Russia	N.Shumeiko, A.Litomin, P.Starovoitov, V.Rumiantsev, O.Dvornikov, V.Tchekhovsky, A.Solin, A.Tikhonov
	Institute of Theoretical and Experimental Physics – Moscow, Russia	M.Danilov, V.Kochetkov, I.Matchikhilian, V.Morgunov, S.Shuvalov
	Lebedev Physics Institute – Moscow, Russia	V. Andreev, E. Devitsin, V. Kozlov, P. Smirnov, Y. Soloviev, A. Terkulov
	Moscow Engineering and Physics Institute- Moscow, Russia	P.Buzhan, B.Dolgoshein, A.Ilyin, V.Kantserov, V.Kaplin, A.Karakash, E.Popova, S.Smirnov
	Moscow State University Moscow, Russia	P.Ermolov, D.Karmanov, M.Merkin, A.Savin, A.Voronin, V.Volkov

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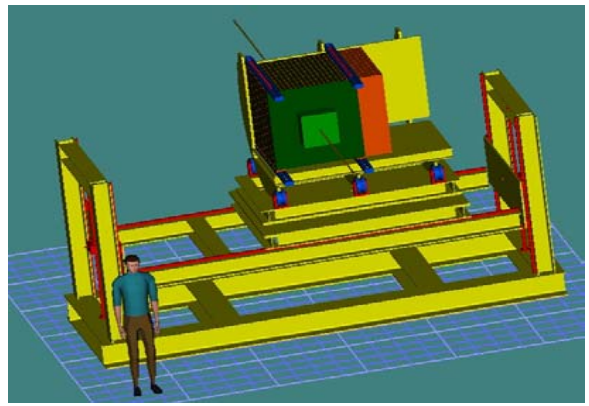
Table 2.b Part 2 of the list of the participating institutions and personnel in ILC test beam program.

Institutions/Collaborations		Personnel Names
CALICE	Laboratoire de l'Accélérateur Linéaire – Orsay, France	B.Bouquet, J.Fleury, G.Martin, F.Richard, Ch. de la Taille, Z.Zhang
	LPNHE - Université de Paris 6 et 7, France	A. Savoy-Navarro
	Charles University – Prague, Czech	S.Valkar, J.Zacek
	Institute of Physics, Academy of Sciences of the Czech Republic – Prague, Czech	J.Cvach, M.Janata, M.Lokajicek, S.Nemecek, I.Polak, J.Popule, M.Tomasek, P.Sicho, V.Vrba, J.Weichert
	Institute of High Energy Physics – Protvino, Russia	V. Ammosov, Yu.Arestov, B.Chuiko, V.Emelianv,V.Gapienko, A.Gerasimtsov, Y.Gilitski,V.Koreshev, V. Lishin, V.Medvedev, A.Semak, V.Shelekhov, Yu.Sviridov, E.Usenko, V.Zaets, A.Zakharov
	School of Electric Engineering and Computing Science, Seoul National University	Ilgoo Kim, Taeyun Lee, Jaehong Park, Jinho Sung
University of Chicago		M. Oreglia
University of Oregon		R. Frey, D. Strom,
Stanford Linear Accelerator Laboratory		M Breidenbach
University of Kansas		G. Wilson, P. Baringer, A. Bean,
University of Colorado		U. Nauenberg
University of Iowa		Y. Onel
University of Washington		Tienchi
Fermilab		E. Ramberg, R. Yarema, H.E. Fisk,
University of Oklahoma		P. Skubic
Frascati, Italy		M. Piccolo, F. Cheechia
Asian Collaborators should be in here!!		



CALICE module test stand

- This proposal needs a long tem occupation (> 1 year) in MTBF.
- They need a broad range of particle types (e,π,μ,p)
- Requests for high energy electrons (>25 GeV) and low energy pions (1 GeV) can't be met by current facility.
- Currently at CERN SPS test beam for rest of 2006.
- Have indicated they would like to move to Fermilab test beam in 2007

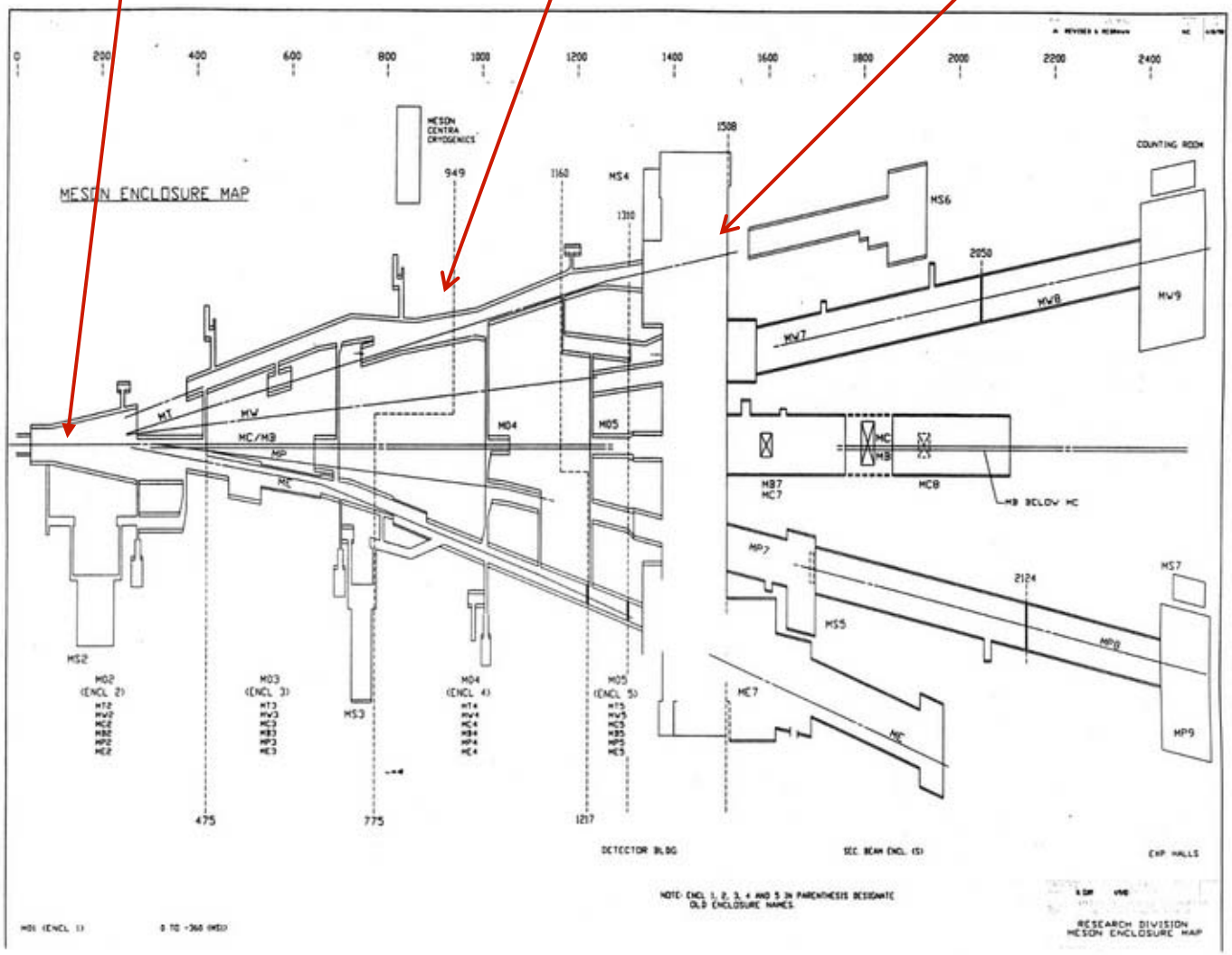
Upgrading the Test Beam

- Several experiments (ILC, NOVA, MINERVA) would like to see low energy test beams at Fermilab.
- Low energy (1 GeV) pions and electrons are very difficult in the current test beam due to length of beamline and sheer number of windows, scintillators, etc.
- The External Beams Group is working on a design now to install a movable target in the M03 or M04 enclosure and possibly redesign the downstream part of the beamline.
- Low current power supplies and Hall probes will be installed on many of the beamline elements.
- These changes will increase rate of 1 GeV pions by ~50-100.

Meson Detector Building

Current 40 cm Al target

Proposed new target location



Summary

- The Fermilab Meson Test Beam Facility is in full operation and supporting multiple users.
- Several groups ran simultaneously near the end of the last running period and obtained good quality data. Some of these will be running again this summer or fall.
- Additional groups have also expressed serious interest in running this year and can likely be supported.
- A larger scale ILC calorimetry test setup will probably come to Fermilab in 2007. That setup will compromise the flexibility of the MTest facility.
- An augmentation to the MTest beamline is being designed by the External Beams Group. This design would increase the flux of low energy pions in the beamline.